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LAUNCHING PROGRAM AT ADELIE LAND, DECEMBER 1966 TO FEBRUARY 1967

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NATIONAL CENTER OF SPACE RESEARCH

SPACE CENTER OF BRETIGNY

DIVISION OF SOUNDING ROCKETS AND BALLOONS

Launching Program at Adelie Land

December 1966 - February 1967

TABLE OF CONTENTS

LAUNCHING PROGRAM AT ADELIE LAND, DECEMBER 1966 TO FEBRUARY 1967 /1*

The launching program of the French Dragon sounding rocket from Adelie Land during December 1966 to February 1967 is outlined briefly, with position maps, payload diagrams, and vehicle sketches. Scientific objects primarily concern determination of the anomalies in the upper atmosphere, centering over the magnetic noon. Data collection and reduction is believed to be facilitated by the favorable position of the French Polar Expedition Station at Dumont d'Urville, within the polar cap of highly deformed lines of force of the earth's magnetic field and practically coinciding with the inclination pole where the magnetic field in the vicinity of the ground surface is vertical. Scientific equipment for measurement of electron density and electron temperature, spectrometry of electrons and protons, and ionization mechanism is described, followed by a brief discussion of the configuration of the vehicle, flight sequence, general launch conditions, and program contractors.

1. Introduction

The National Space Research Center has scheduled a series of launchings at Adelie Land during the summer launch program, between December 1966 and February 1967.

The launchings of four Dragon sounding rockets will take place from the Dumont d'Urville station of the French Polar Expeditions.

The French polar expeditions "Paul-Emile-Victor missions" will take over the logistic support of this program, which will be conducted for the benefit of the Ionospheric Research Group (I.R.G.).

This launching program will be the first ever effected by any country on the Antarctic Continent.

2. Launching Program for Adelie Land; "General Principles" /2

It seems entirely justified to ask for the reasons that induced the scientists to undertake launchings at a site whose access is still difficult, when any number of more or less well-equipped launch sites are available in various regions of the globe.

The basic reason lies in the favorable location of the Dumont d'Urville

* Numbers given in the margin indicate pagination in the original foreign text.

base for observations of certain types of geophysical phenomena. To this must be added the existence of an important geophysical observatory which has been operating for close to ten years and which furnishes a context of observations within the frame of which the reduction of in-situ measurements, obtained by means of rockets and of necessity brief in duration, is greatly facilitated.

2.1 Geophysical Significance of the Dumont d'Urville Site

For geophysicists, concerned with studying the terrestrial environment, the various regions of the globe are by no means equivalent.

In general, the earth's magnetic field governs the upper-atmosphere phenomena; from the viewpoint of the earth's magnetic field, the Dumont d'Urville base occupies a rather exceptional position. /3

This magnetic field, in first approximation, can be considered that of a bar magnet placed at the center of the globe and having its axis make an angle close to 11° with the geographic axis. Based on measurements made in all regions of land masses and oceans, it has been possible to calculate the form of the lines of force of this magnetic field with satisfactory accuracy.

Let us say that a point on the earth's surface can be characterized by the distance at which the line of force, issuing from this point, intercepts the plane of the magnetic equator, i.e., the plane of the great circle perpendicular to the axis of the bar magnet.

Figure 1, superposed on a contour of the Antarctic Continent, shows the curves joining the points for which this distance has a given value. It is quite obvious that the highest values of this parameter are reached over the portion of the coast which stretches from the Dumont d'Urville base to the Wilkes Station. In fact, only one of the existing stations has a distinctly higher value, namely, the Vostok Station located at the interior of the Continent.

The point around which the broken curves or magnetic parallels are clustered corresponds to a line of force which, in the absence of any perturbing effect, extends to infinity; this is the constant pole. In the Southern Hemisphere, the permanent pole is more than 15° from the geographic pole, and the magnetic parallels are practically circular; conversely, in the Northern Hemisphere, the permanent pole is less than 10° from the geographic pole, and the magnetic parallels are elongated ellipses. This means specifically that, in data re- /4
duction, the Antarctic is more suitable than the Arctic for separating the effects linked with the geographic latitude from those depending on the magnetic latitude.

Thus, Dumont d'Urville is located in the most favorable sector of the Continent. In addition, this station practically coincides with the inclination pole. This is the point at which the magnetic field, in the vicinity of the ground surface, is vertical. Because of the existence of regional deformations, this point does not coincide with the permanent pole. In addition, the point is subject to a slow drifting motion; this motion, over the course of decennials elapsed, has shifted the point into the immediate neighborhood of the Dumont d'Urville base (Fig.3).

In reality, measurements made over several years by means of satellites inserted into highly eccentric orbits show that, at a great distance from the earth, the geometry of the lines of force of the magnetic field deviates considerably from the image given by the bar magnet. This is due to the fact that the earth is always immersed in a highly rarefied (one particle per cm^3) and high-speed ($\simeq$500 km/sec) stream of ionized gas which is constantly emitted by the sun. This "solar wind" deforms even the farthest lines of force and tends to stretch them out in an antisolar direction.

The classical auroral zone, i.e., the zone in which the polar aurorae are produced with maximum frequency, is located approximately at the boundary between the regions of low latitude from which less deformed lines of force emerge and the regions of the polar caps whose lines of force are highly deformed (Fig.3).

The Dumont d'Urville base is located for the most part within these caps. /5
For French scientists this is the only relatively easily accessible point where they can study the characteristic phenomena of these regions.

2.2 Scientific Objectives of the Program of the Ionospheric Research Group

The ground observations made at Dumont d'Urville since the beginning of the International Geophysical Year have permitted demonstrating anomalies of behavior in the upper atmosphere, which are concentrated over the magnetic noon. This is the designation for the instant at which the sun passes into the plane of the ideal line of force issuing from the station.

These anomalies manifest themselves particularly by

increase in ionospheric absorption;
fading of the radio echoes over the higher regions of the ionosphere (F-region).

Various explanations for these phenomena can be imagined; however, it is difficult to obtain an accurate concept of the events taking place without actually making in-situ measurements. Therefore, it was suggested to use onboard equipment of rockets for measuring two characteristic parameters of the traversed ionospheric regions, namely, electron density and electron temperature.

In addition, it was suspected that the observed anomalies may be connected with the incidence of high-energy particles, coming from the sun or acceler- /6
ated in the distant regions of the terrestrial environment and entrained along the lines of force of the magnetic field. Thus, the flux density of these particles (electrons and protons) will be measured together with the distribution of their energies and their angle of incidence.

3. Scientific Instrumentation

The nose cones of the Dragon sounding rockets, carrying the scientific equipment, will be used for a total of four experiments each, which will be briefly reviewed below.

a) Measurement of Electron Density

In this experiment, the number of electrons per cm^3 in the traversed regions are measured. For this, a probe is used, developed by Professor Sayers of the University of Birmingham. This probe consists of two plane-parallel plates constituting a capacitor whose dielectric is formed by the ambient gas. As soon as this gas becomes ionized, the electrons contained therein will influence its specific inductance and thus also the capacitance of the capacitor. From the magnitude of this capacitance, the electron density can be derived.

b) Measurement of Electron Temperature

In an ionized gas, containing positive ions, electrons, and neutral molecules, the temperature of each of its constituents can be determined, a temperature which the kinetic theory of gases relates with the mean velocity of the /7
particles of each species. In a gas in equilibrium, these temperatures are equal. However, the ionization mechanism producing the electrons is capable of imparting to them, at the instant of their emission, a temperature much higher than that of the ambient medium. From the laws of mechanics it then follows that, because of their low mass, these electrons have extreme difficulty to dissipate, during collisions, their excess energy and to return to equilibrium with the environment. Consequently, measuring the electron temperature yields data on the nature and intensity of the mechanism of ionization.

This temperature is measured by a combination of two spherical Langmuir probes developed by Professor Sayers.

c) Spectrometry of Electrons and Protons

These two experiments are identical in principle, and the detectors differ only by the fact that the proton detectors are provided with a magnet whose magnetic field repulses the electrons.

Each detector consists of a crystal of activated cesium iodide, observed over a photomultiplier. An incident particle striking the crystal produces a scintillation whose intensity is dependent on the energy of the incident particle and which is converted into an electric signal by the photomultiplier.

This furnishes information on the number and intensity of the incident particles.

A thin vacuum-deposited metal coating renders the surface of the crystal /8
opaque and thus prevents solar light from reaching the photomultiplier.

In addition, these counters are directive; two point toward the front, two toward the rear, and two others sweep the perpendicular directions thanks to the rotation of the rocket itself. This yields data on the distribution of the flux of incident particles as a function of the direction.

4. Summary Description of the Nose Cones (Fig.4)

The MATRA Co. has been in charge of producing the payloads for the rockets. The nose cones, housing the scientific equipment, have a length of 1.66 m at a weight of 93 kg.

The entire instrumentation of the nose cone is grouped about a single module. This capsule is covered by a fairing to protect the various apparatus while passing through the dense atmospheric layers. The payload fairing is jettisoned 53 sec after liftoff of the rocket, by means of a pyrotechnic charge placed at the top of the module.

The module itself is divided into three sections:

The upper conical portion carries the pyrotechnic ejection charge at its apex, the temperature and density probes, the magnetometer, and the batteries. The probes which can be deployed in flight, are kept at 90 cm from the axis /9
of the nose cone so as to keep them outside of the sheath surrounding the body of the rocket itself.

The central cylindrical section houses six particle detectors (three proton detectors and three electron detectors) as well as the two telemetry transmitters. Of the three electron detectors, two are arranged along the axis of the rocket, one pointing upward and the other pointing downward. The third detector is mounted along the axis perpendicular to that of the rocket. The aperture angle of each of these detectors is approximately 20°.

The proton detectors are of identical design and are mounted in the same manner as the electron detectors. Discrimination of electrons and protons is carried out by auxiliary devices so designed that the influence of protons on the measurement of electrons or the influence of electrons on the measurement of protons is prevented from introducing an error exceeding 1% of the measuring range, taking the energy spectrum of the investigated particles into consideration.

So as to prevent the longitudinal detectors from sighting the body of the rocket, a device permits their positioning at about 70 cm from the axis of the nose cone, after ejection of the shroud. Another device permits tilting of the perpendicular detectors. The trailing end of the nose cone, located above the front end of the propulsive unit, contains the cut-in junction box and the commutators.

5. Brief Description of the Rocket (Fig.5) /10

The Dragon is a two-stage vehicle, manufactured by Sud-Aviation. Propulsion is by monolithic propellant grain, put in place before shipping of the rocket. This type of rocket is more suitable for use on improvised launching sites than liquid rockets; for example, several of these rockets have previously been launched in Iceland under the auspices of the Aeronomy Department of the National Scientific Research Center, the National Space Research Center. The second stage of the Dragon and its payload will reach an altitude close to 350 km. Such a high altitude is necessary for proper functioning of the electron and proton spectrometry experiment. In fact, at very low altitudes, the distribution of the arrival directions is perturbed by collisions with neutral molecules, rendering an interpretation of the data difficult. This was the reason for giving preference to the Dragon rocket over the Centaure which is of similar design but lighter in weight and whose maintenance would have been much easier.

In all, four launchings are scheduled of which three, to be made in rapid succession, are expected to yield information on the evolution of conditions over one and the same day.

The temperature conditions at Adelie Land have induced the technicians of the CNES to develop a heating system for the vehicles on the launch pad. Excessive variations in the propulsion units would lead to a separation between the powder grain and the outer shell of the first stage, resulting in an explosion on the pad.

6. Flight Sequence of the Vehicle /11

The flight sequence is as follows:

T = 0	firing of the first stage
T + 0.4 sec	liftoff from pad, cut-in of spin mechanism
T + 0.6 sec	burnout of spin mechanism
T + 1.4 sec	fallaway of spin mechanism
T + 16 sec	burnout of first stage
T + 18.2 sec	separation of first from second stage
T + 18.4 sec	ignition of second stage
T + 37 sec	burnout of second stage
T + 53 sec	jettison of nose cone fairing
T + 54 sec	release of yoyo
	extension of detectors
	extension of probes
T + 5 min	culmination
T + 10 min	end of flight of vehicle.

Note

The yoyo device, mounted to the vehicle, acts as a despin mechanism and reduces the spin rate from about 5 rps to 1.5 rps, so as to permit egress of the detectors and probes.

7. <u>General Conditions of the Program</u> /12

The launching program is scheduled for Adelie Land, from the Dumont d'Urville station of the French Polar Expeditions.

The necessary equipment is transported to Adelie Land by the French Polar Expeditions. The departure of the ship from LeHavre is scheduled for the beginning of October 1966.

The personnel of the team of the National Space Research Center will leave France at the end of November, to embark at Hobart (Australia).

The program will be executed at the station of the French Polar Expeditions, which ensures vital logistic support. Certain installations required for these launchings have been erected by the Expeditions within the past year, including construction of an assembly hangar for the vehicles and construction of a cemented platform for launching the rockets.

Execution of a launching program at Adelie Land is made extremely difficult for numerous reasons:

1) Transport and setup of extensive equipment is necessary, including: telemetry station, visual-display station, ramp, units for remote control of the ramp, control and firing of the vehicle itself, equipment for assembly and readying of the vehicles and nose cones.

This equipment alone has a bulk requirement of 300 m^3 and a weight of 80 tons.

2) In all, four vehicles with their nose cones must be readied at the same time, so as to effect the launchings within a very short time interval.

3) The duration of the program has a time limit. The arrival of the team is scheduled for approximately December 15, 1966 while its departure must take place by the beginning of February 1967. Channeling the equipment, readying the nose cones, assembling the vehicles, actual firing, disassembly and crating /13
must all be done within 45 days.

4) The launching conditions themselves are severe: launching on a day of medium activity at a wind below 12 m/sec.

5) Working conditions are rendered extremely difficult by meteorological conditions.

6) The personnel participating in the program is limited in number for reasons of ship accommodation and housing. Therefore, the personnel had to be reduced to 26 members.

The CNES has developed a mobile unit to carry out programs of this type. In all, two programs have already been executed, in 1964 and 1965 in Iceland. This mobile unit is autonomous and permits firings in any country not having the necessary installations.

All equipment of this base is housed in cabins that can be transported by air, consisting of the following: a "fire-direction" cabin; a "ramp-control and vehicle-launch" cabin; a receiving and recording station for telemetry data; a cabin for visual display of both vehicle and scientific parameters before firing; a transmission unit; an electric unit; a laboratory; and a general workshop.

The personnel participating in the program comprises:

nine staff members of the CNES
three staff members of the G.R.I. (I.R.G.)
five staff members of the MATRA
eight staff members of Sud-Aviation
one staff member of SODETEG.

APPENDIX /14

LIST OF PROGRAM CONTRACTORS

Vehicles and Starting Equipment: Société Sud-Aviation

Study and Manufacture of Nose Cones: Société des Engins MATRA

Structure (study, prelaunch tests)
Wiring and cables
Installation of equipment (power supply, start-up)
Adjustment of telemetry system.

Subassemblies:

Telemetry: Sud-Aviation; transmitters and voltage regulators
Voltage regulators: SAT
Subcommutator: LRCE
56, rue Bronzac
94 - L'Hay-les-Roses
Batteries: Société SAFT
Magnetometers: Compagnie des Compteurs (Montrouge)
Timing devices: MAUREL

Scientific Equipment:

Photomultipliers: Radiotechnique Hyperelec 19 - Brive
Electronic equipment for detectors: Intertechnique
78 - Plaisir
Electronics of the probes: Promelec
17, rue Thiers
92 - Boulogne-Billancourt

Power Equipment for the Mobile Unit: SEMACI /15
70, rue Jean-Jaurès
94 - Villejuif

Power Pack: ANAN

Equipment for Telemetry and Visual Display Stations: Les Appareillages TELEMO
56 bis, rue Perronnet
92 - Neuilly-sur-Seine

Electric Wiring: Etablissements BUB
32 bis, rue Maurice Nogues
91 - Viry-Chatillon

<u>General Wiring</u>	Geoffroy-Delore 134, Boulevard d'Haussmann Paris 8e
<u>Stabilized Power Supply</u>	Etablissements FONTAINE 20, rue Arago 91 - Chilly-Mazarin
<u>Interphones</u>	La Signalisation 138, rue du Chevaleret Paris 13e
<u>Shelters</u>	AERAZUR 58, Boulevard Galliéni 92 - Issy-les-Moulineaux
<u>Cabins</u>	Etablissements SPAIR 24, rue du Rocher Paris 8e

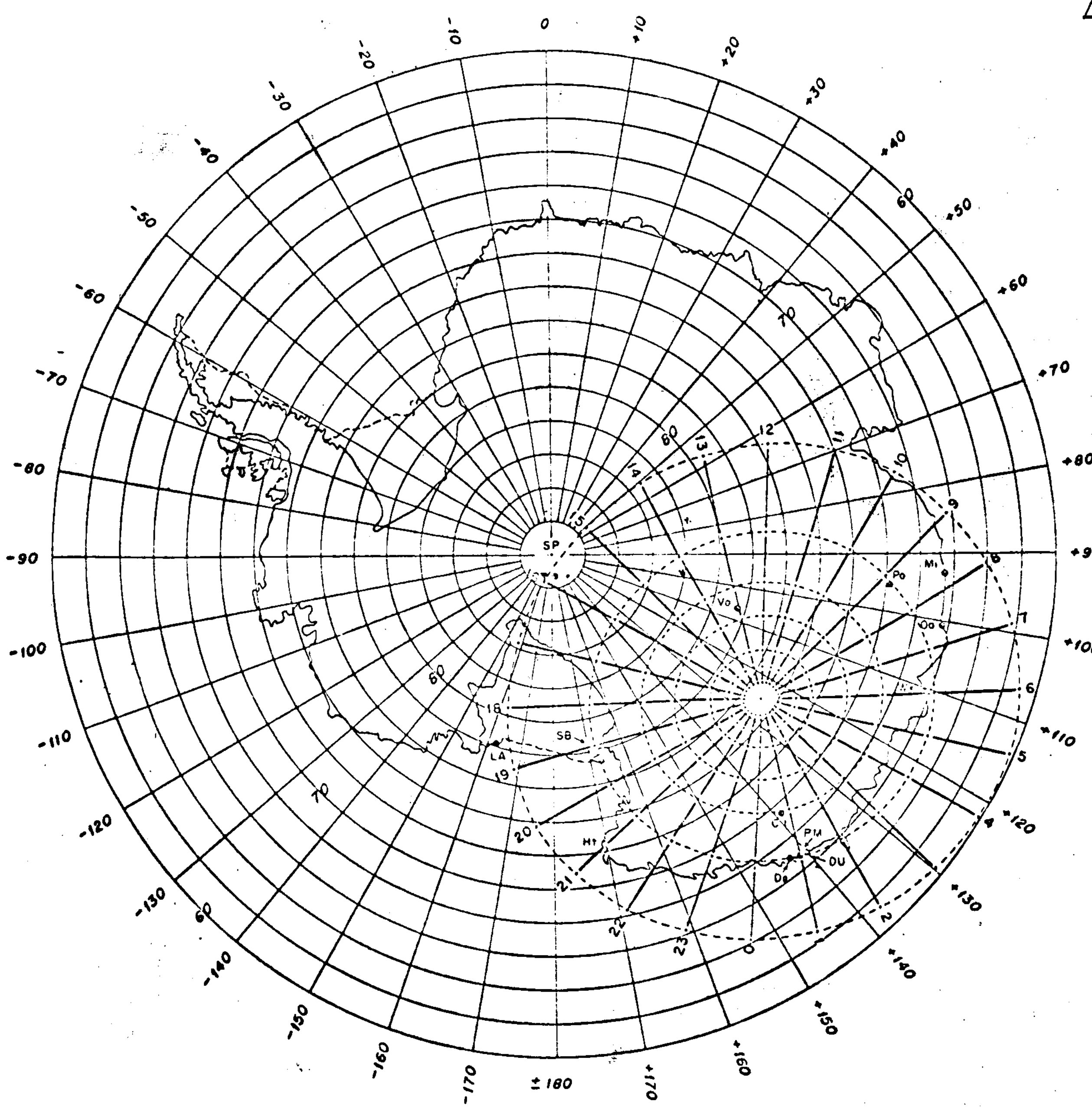

Fig.1

SP : South Pole	Po : Pionerskaya	LA : Little America
Wk : Wilkes	Vo : Vostok	De : Cape Denison
Oa : Oasis	DU : Dumont d'Urville	Ct : Charcot'
Mi : Mirny	SB : Scott Base	PM : Port-Martin

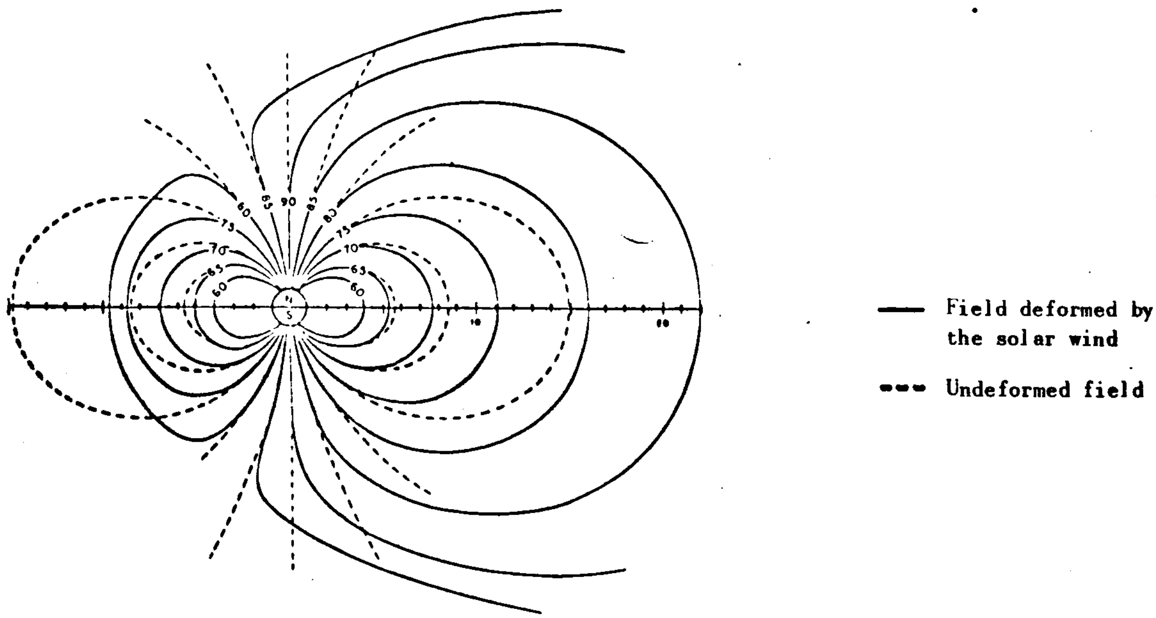

Fig.2 Cut through a Meridian Plane Passing through the Sun-Earth Line of the Terrestrial Magnetic Field.

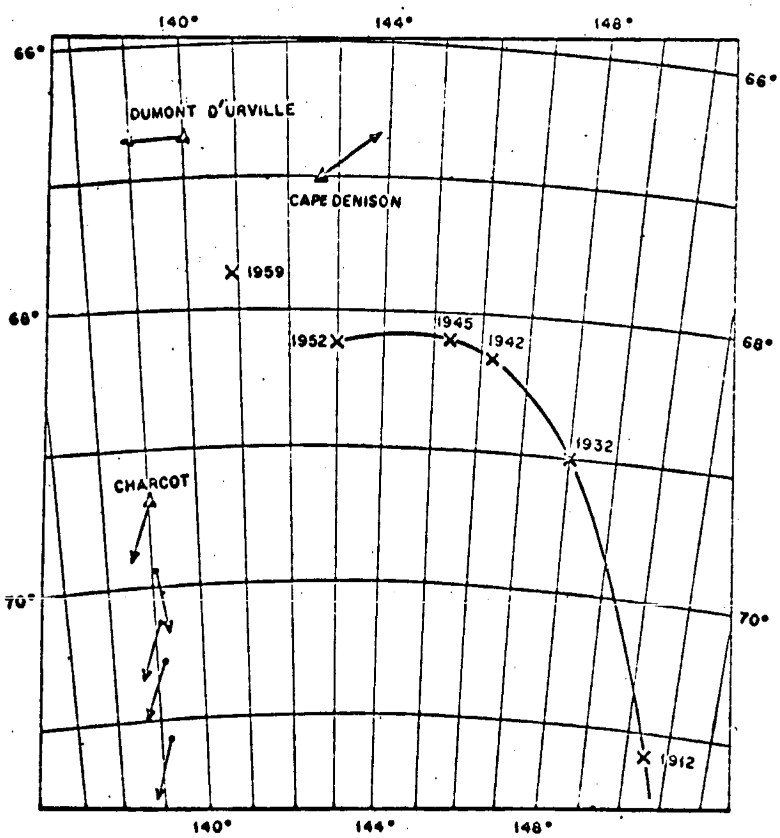

Fig.3 Shift of the North-Seeking Pole since the Beginning of the Century.

/18

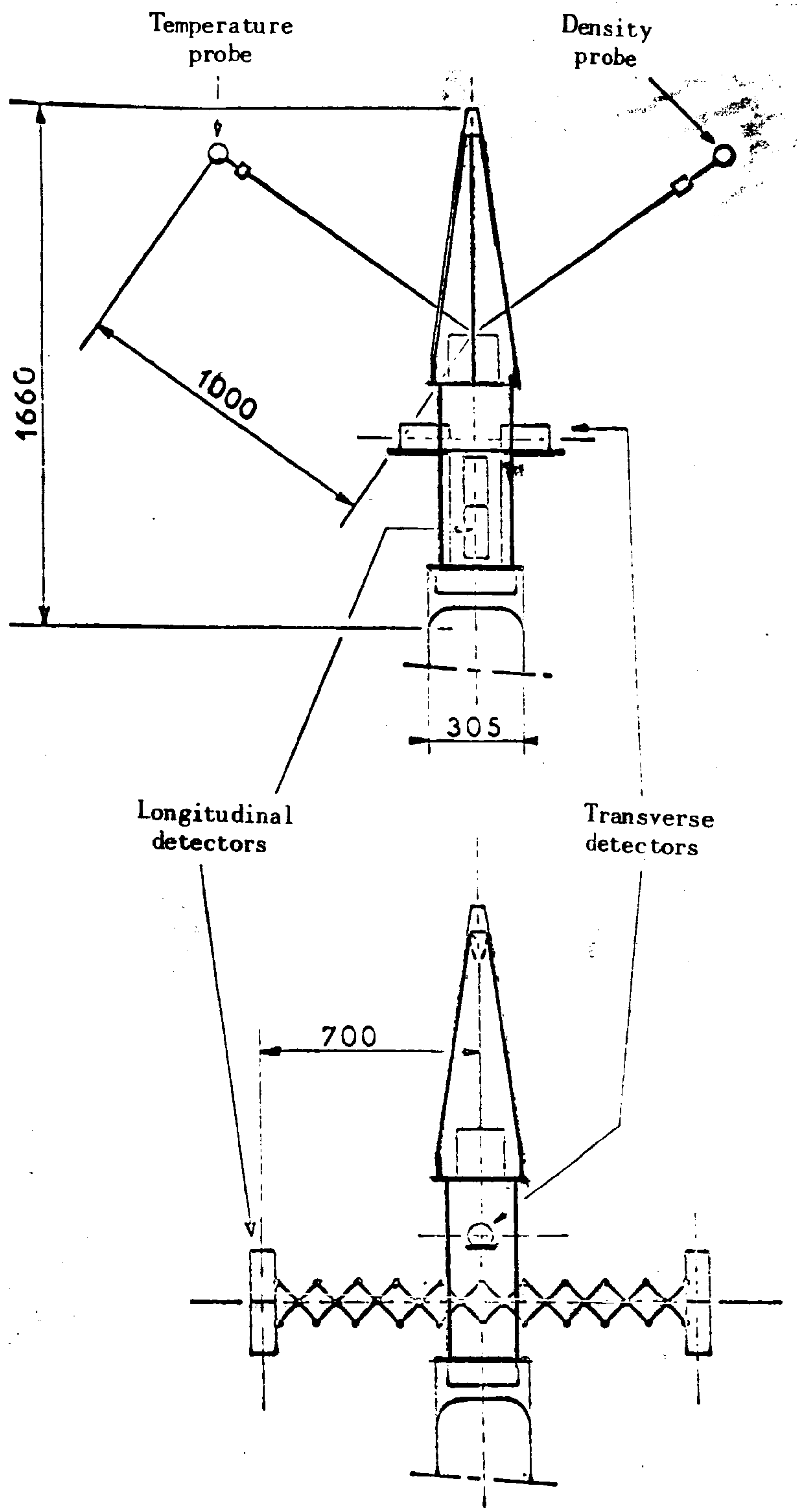

Fig.4 Payload of the Dragon

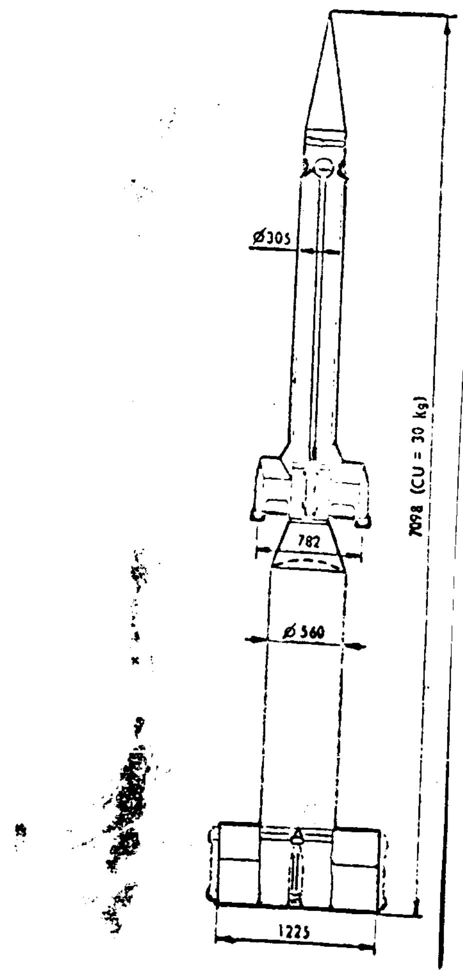

Fig.5 Dragon Vehicle